

Inflation, Growth, and Central Banks

Theory and Evidence

José de Gregorio

Inflation limits economic growth by reducing the efficiency of investment rather than its level. An effective way of achieving low inflation is to establish an independent central bank.



Summary findings

De Gregorio reviews the theory and evidence on inflation and growth and provides additional empirical evidence for a large cross-section of countries.

The evidence, he reports, suggests a robust negative relationship between inflation and growth. He argues that inflation limits growth mainly by reducing the efficiency of investment rather than its level. But this finding is difficult to explain using traditional theories that rely on the effects of inflation on employment, which are not supported by the data. Explanations focusing on the effects of inflation on the allocation of talents and the functioning of financial markets may help in understanding better the long-run relationship between inflation and growth.

De Gregorio also reviews the theoretical and empirical literature on how central banks affect inflation and

output growth. An independent central bank can be effective in reducing inflation if the public perceives that it is tough on inflation. But inflation persists because the cost of reducing it is high — the most evident cost being the loss of output from disinflation.

De Gregorio concludes that although serious progress has been made in recent years in assessing empirically how central banks affect macroeconomic performance, the results are still inconclusive. The empirical evidence shows a negative correlation between inflation and central bank independence, especially in OECD countries, but the effects on growth are less conclusive. It is fair to say that the bulk of the evidence suggests that central bank independence produces lower inflation at no real costs.

This paper — a product of the Macroeconomics and Growth Division, Policy Research Department — is part of a larger effort in the department to examine the determinants of economic growth. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Kari Labrie, room N11-055, telephone 202-473-1001, fax 202-522-3518, Internet address klabrie@worldbank.org. February 1996. (48 pages)

The Policy Research Working Paper Series disseminates the findings of work in progress to encourage the exchange of ideas about development issues. An objective of the series is to get the findings out quickly, even if the presentations are less than fully polished. The papers carry the names of the authors and should be used and cited accordingly. The findings, interpretations, and conclusions are the authors' own and should not be attributed to the World Bank, its Executive Board of Directors, or any of its member countries.

Inflation, Growth and Central Banks: Theory and Evidence

José De Gregorio *
Ministry of Finance, Santiago, Chile

JEL Classification Numbers: E31, E58, O42.

*A previous version of this paper was presented at the Latin American Seminar on Economic Growth organized by the Government of Colombia, the World Bank, and the IDB and held in Bogota, and at a seminars in the Centro de Estudios Públicos, Universidad Católica, and Universidad de Chile. I am grateful to Andrés Bianchi, Bill Easterly, Juan Andrés Fontaine, Roberto Junguito, Francisco Rosende and seminar participants for valuable discussions.

1 Introduction

For a long time economists have been studying the costs of inflation.¹ For example, it has been argued that inflation is costly because it induces the public to hold insufficient amounts of cash balances, leading to welfare losses. This has been the basis for Friedman's proposal of zero nominal interest rate (Friedman, 1969) to achieve full liquidity. It has also been stressed the effects of inflation on increasing uncertainty, which affects adversely the public's ability to make their best decisions. Therefore, a reduction of inflation may increase well being by reducing distortions. More recently, the static losses alluded above have been amplified by theoretical models and empirical evidence that show that inflation has also negative effects on the rate of growth of an economy.

Since everybody would agree that inflation is costly, it is then necessary to ask why it is so difficult to achieve low inflation, specially in situations of extreme inflation where a lower level of inflation would be clearly beneficial. The straightforward answer is that inflation remains high because it is costly to reduce it. The most evident cost is the loss of output stemming from a disinflation. The existence of sticky prices and credibility problems are responsible for the slow response of the private sector to attempts by the authorities to reduce inflation, and consequently, for the output losses associated with a reduction of inflation (see, e.g., De Gregorio, 1995). Therefore, it becomes crucial to know how can those recessionary costs be reduced. This task requires, among other things, to understand the institutional factors that affect inflation. A substantial body of literature has focused on the role of central banks in increasing credibility and reducing the costs of achieving and maintaining low inflation.

This paper reviews the literature on inflation, growth, and the effect of central bank independence on economic performance. Theory suggests that inflation affects growth by reducing the rate of investment as well as the efficiency of investment. In reviewing the existing empirical evidence, which is complemented in this paper with additional cross-country growth regressions, special emphasis is placed in disentangling both channels through which inflation affects growth. It is also discussed the importance

¹A classical reference on this topic is Fischer and Modigliani (1978). For a recent analysis see Lucas (1993), Braun (1994) and the survey by Driffill, Mizon and Ulph (1990).

of some outlier countries and some other relevant econometric issues. The evidence discussed in this paper indicates that indeed inflation has a negative effect on growth and it is mainly due to a reduction in the productivity of investment. Although high inflations are shown to be the most harmful for growth, it is found that even in low-inflation industrialized countries there is a negative relationship between inflation and growth.

Establishing an independent central bank is an effective tool to reduce inflation as long as the public perceive that the central bank is tough against inflation. In reviewing the literature this paper uses a framework that incorporates explicitly, in addition to a central bank that conducts monetary policy, a fiscal authority that needs to finance the budget. It is shown that moving from a fully dependent central bank to an independent central bank with more emphasis on fighting inflation than society's would like is welfare increasing. But, when the central bank places excessive weight on reducing inflation it may induce excessive output fluctuations and inefficiencies on fiscal policy. The empirical evidence shows that there is a negative correlation between inflation and central bank independence, specially in OECD countries, but the effects on growth are less conclusive. It is fair to say, however, that the bulk of the evidence suggests that central bank independence produces lower inflation at no real costs.

The paper follows in four sections. Section 2 discusses theories of inflation and growth. Then, Section 3 discusses the effects of central bank independence on inflation and macroeconomic performance. Section 4 discusses the empirical evidence on inflation and growth, and then on central bank independence and macroeconomic performance. Finally, Section 5 summarizes the main conclusions.

2 How does Inflation Affect Economic Growth?

In this section I review the theory on inflation and long-run growth. In the short run inflation is costly and entails welfare losses, but I will ignore those short run considerations. However, it is important to note that as long as inflation has effects on long-run growth, the standard static welfare losses from inflation may be magnified. This could add significantly to current estimations of the welfare losses of inflation.

2.1 The neoclassical approach

In their classical articles Mundell (1965) and Tobin (1965) predicted a positive correlation between the rate of inflation and the rate of capital accumulation. The Mundell-Tobin effect relies on the substitutability between money and capital, by which an increase in the rate of inflation results in an increase in the cost of holding money and a portfolio shift from money to capital. This change in portfolio composition brings an increase in capital accumulation and a decline in the real interest rate. Finally, the increase in the rate of capital accumulation induces a higher rate of growth.

The main criticism to the Mundell-Tobin effect is that money is assumed to be demanded because it is a store of value. This assumption seems to be implausible since nowadays money is dominated in rate of return by other assets.² Indeed, in modern economies is unlikely that individuals demand money to save. Instead, money is demanded because it is necessary for transactions. One could argue, however, that in formerly centrally planned economy individuals use money to save, and in fact, a reason for the so-called monetary overhang is that households only way to save is holding money. However, in those economies people use money to save precisely because the possibility to save in “capital” is not available, due to the lack of financial markets, and therefore money is the only store of value and inflation cannot produce a portfolio shift. The development of capital markets, rather than an increase in inflation, will induce a shift from money to capital.

Most of the subsequent literature in the neoclassical tradition follows the seminal work of Sidrauski (1967) in the context of an infinitely-lived representative agent model where money is demanded because it provides utility. In Sidrauski’s model money is superneutral, that is the rate of money growth has no real effect on the steady state. Subsequent work, however, extended the model to show that superneutrality is a rather special case, and in most general cases inflation would reduce the steady-state stock of capital, thus resulting in a reversal of the Mundell-Tobin effect.³ For example, this may result from the fact that money provides liquidity services by freeing resources and output that otherwise would be devoted to sustaining the

²This criticism was first raised by Levhari and Patinkin (1968).

³For further analysis see the survey by Orphanides and Solow (1990).

exchange system (Dornbusch and Frenkel, 1975). This may also result from changes in the labor supply when leisure is introduced as an additional argument in the utility function (Brock, 1974). Another relevant case is when money is used as an input in the production process (Fischer, 1983), or finally, when money is used to buy capital goods (Stockman, 1981). In all of these models money and capital can be interpreted as being complements.⁴

Most of the literature discussed so far focuses on the effects of inflation on the steady state level of output. There is usually no effects on the steady state rate of growth, since the models are framed in the context of economies that do not display permanent growth. Indeed in the traditional literature the only source of growth is the exogenous rate of productivity growth, which cannot be affected by policy. It was not until developments in the theory of economic growth allowed to understand how economies may endogenously display permanent growth that the neoclassical framework was extended to incorporate the effects of inflation in long run growth. Recently, De Gregorio (1993) and Jones and Manuelli (1993) have used the endogenous growth framework to extend the results from the effects of inflation on per capita output to the effects of inflation on the rate of growth of output.

To understand how inflation affects long-run growth consider the following production function:⁵

$$y_t = \theta f(k_t, \ell_t) \quad (1)$$

where y_t is output at period t , θ is a technological parameter, and k_t and ℓ_t are the stock of capital and employment in period t , respectively. After log-differentiating (1) we obtain the following expression for the rate of growth of the economy:

$$\gamma = \theta f'(k_t, \ell_t) i \quad (2)$$

where γ is the rate of growth of output ($\gamma \equiv d \log(y_t)/dt$), $\theta f'(k_t, \ell_t)$ is the marginal productivity of capital, and i is the investment rate, $(1/y)(dk/dt)$. In the traditional growth model the assumption of decreasing returns to capital with the marginal productivity of capital going to zero as the capital stock grows to infinity ensures

⁴In a different framework McKinnon (1973, ch. 5) argues that money and capital are complements in economies with underdeveloped financial markets.

⁵For simplicity I assume there is no depreciation.

that unless productivity is assumed to grow (θ not to be a constant) there is no per-capita output growth in the steady state. In contrast, the new endogenous growth models have focused in cases where $f'(k_t, \ell_t)$ remains always positive.⁶ In this type of models it is no longer necessary that some exogenous factor, such as θ , be the source of output growth.

According to equation (2) growth may be generated by either, an increase in the marginal productivity of capital $\theta f'(k_t, \ell_t)$ or an increase in the rate of investment. In the empirical section of this paper I discuss the effects of inflation on growth through the two channels: the *efficiency channel* to refer to the increase in $\theta f'$, and the *investment channel* to refer to the increase in i . In endogenous growth models capital must be interpreted in broad terms, to include not only physical capital, but also human capital, knowledge, organizational capital, etc., and thus, an increase in the rate of investment should also include, for example, the rate of accumulation of human capital.

In a closed-economy investment equals savings, and the interaction between them will also determine the return on capital. The Mundell-Tobin effect focused on the impact that inflation has on savings. Through a portfolio shift, inflation would increase the rate of savings, resulting in an increase in investment and growth, and a decline in the real interest rate.

In contrast, in models such as Stockman (1981), De Gregorio (1993) and Jones and Manuelli (1993) inflation affects growth because it reduces the investment rate. Inflation can be considered to be a tax on investment, and therefore would increase the profitability required to undertake an investment project and would reduce the real interest rate relevant for savings. In Stockman (1981) and De Gregorio (1993) money is required to buy capital goods, and hence the effective cost of capital increases with the inflation rate. Jones and Manuelli (1993) assume that there is a nominal rigidity in the tax structure. Specifically they assume that the tax code includes nominally denominated tax allowances.⁷ The result of this imperfection is that as inflation rises

⁶Among the leading examples see Romer (1986), Lucas (1988), Jones and Manuelli (1990) and Rebelo (1991). More involved specifications that emphasize the role of innovation, creation of new products and quality ladders can be found in Grossman and Helpman (1991) and Aghion and Howitt (1992).

⁷It could also be assumed that tax brackets are imperfectly indexed or nominally denominated investment tax credits.

tax allowances decline, and consequently the effective cost of investment increases.

Another mechanism through inflation could affect growth is by distorting the optimal choice between consumption and leisure (De Gregorio, 1993). In this case individuals' decisions, rather than that of firms, affects negatively growth. To illustrate this effect note that equation (2) shows that a decline in $f'(k_t, \ell_t)$ results in a decline in the rate of growth, because capital accumulation becomes less efficient. For simplicity assume that f is linear in k , and therefore f' is an increasing function of ℓ_t . Finally, consider the case where individuals have to choose between consumption and leisure, and to purchase consumption goods individuals face a cash-in-advance constraint. Therefore the effective price of consumption goods will include the rate of inflation, like a tax, since individuals will have to hold money in order to buy consumption goods. Therefore, an increase in the rate of inflation will increase the price of consumption with respect to the price of leisure inducing substitution from consumption to leisure, thereby reducing the labor supply. Hence, an increase in inflation will reduce the efficiency of investment ($\theta f'$) and the rate of growth.

2.2 Reinterpreting the neoclassical approach

In the neoclassical approach *anticipated* inflation has negative effects on growth by changing money demand of consumers and firms. This may of course be narrow, specially given the degree of sophistication of financial markets, which presumably offer a wide range of instruments to hedge against anticipated inflation. Furthermore, in modern economies it is unlikely that most of purchases of capital goods are conducted with money rather than with credit. For these reasons it is important to broaden the interpretation of the models to include more realistic situations. Instead of assuming simply that money is used to buy capital goods, one can think more in general that money facilitates the operation of a firm. High inflation may lead to excessive (nonmonetary) resources being devoted to transactions and cash-management instead of the production of goods and innovation. Firms are also subject to enormous capital gains or losses in countries where chronically high inflation exists. This induces entrepreneurs to spend a considerable amount of time and resources in portfolio management.

Analogously, the variable ℓ can be interpreted more broadly as effort exerted in

the production of goods. In a high inflation economy households also spend resources in protecting themselves against inflation, and in finding arbitrage opportunities that arise in unstable macroeconomic environments. Therefore, one can think of the effect of inflation on labor supply as a simplification for the effects of inflation on effort devoted by workers while performing productive activities.

Overall, inflation provides an incentive for firms and households to devote more resources to activities that are not the engines to sustained growth. This point has been stressed by Baumol (1990) and Murphy, Shleifer and Vishny (1991), who argue that the allocation of talent is an important explanation for growth performance. And the allocation of talent is strongly influenced by institutional factors, such as the macroeconomic environment, which determine the relative rewards for the allocation of resources in activities with different social returns. Leijonhufvud (1977) has specifically argued that in an inflationary environment becomes more important to cope with inflation rather than devote time to ‘real’ activities:

“Being efficient and competitive at the production and distribution of ‘real’ goods and services becomes less important to the real outcome of socioeconomic activity. Forecasting inflation and coping with its consequences becomes more important. People will reallocate their effort and ingenuity accordingly . . .

In short, being good at ‘real’ productive activities—being competitive in the ordinary sense—no longer has the same priority. Playing the inflation right is vital.”

2.3 Inflation, uncertainty and investment

It is part of the conventional wisdom that inflation increases uncertainty in the economy, and this uncertainty is harmful for investment and growth. Let consider first the link between inflation and uncertainty, and then turn to the link between uncertainty and investment.

First, most economists would argue that high anticipated inflation is associated with high variability of unexpected inflation, that is, the uncertainty about inflation rises with the level of inflation.⁸ Therefore, individuals willing to forecast future

⁸For a recent discussion and comprehensive review of the literature see Ball and Cecchetti (1990). See also Ungar

macroeconomic conditions will find more problems in a high inflation environment. However, not only uncertainty about inflation rises, but also relative price variability also increases with inflation. Most of the existing empirical evidence shows that the variability of prices across goods and the variability of prices of a same good across stores increase with the rate of inflation.⁹ As a consequence, the informational content of prices declines with inflation since current prices are a poor predictor of future prices.

The higher uncertainty generated by high inflation has important implications for welfare. In particular, models based on search theory emphasize (see, e.g., Benàbou, 1988; Casella and Feinstein, 1992; and Tommasi, 1993) the distortionary effects of inflation that changes the search intensity of individuals and the monopoly power of firms. Although these welfare effects are extremely important, they will not be discussed further since our interest is on the growth effects of inflation, rather than its static welfare costs.

Also, overall uncertainty about macroeconomic policy certainly increases with inflation. Fischer (1991) has supported this view by arguing that inflation is an “indicator of the overall ability of the government to manage the economy.” And he concludes that “since there are no good arguments for high inflation rates, a government that is producing high inflation is a government that has lost control.” Therefore, in high inflation economies the government will be more prone to introduce price controls, changes in the tax and trade regime, etc. all of which increase uncertainty about the future, thereby affecting investment decisions.

The next question is how does uncertainty affect investment. In this respect the theoretical literature has made significant progress in recent years in analyzing the relationship between uncertainty and investment. Initially, Hartman (1972), and later Abel (1983), showed that in an economy without frictions an increase in uncertainty about prices would increase investment. The reason is that under constant returns to scale the marginal profitability of capital is a convex function of input and output prices. Therefore, by Jensen’s inequality, an increase in uncertainty about prices, would increase the expected marginal return on capital, and hence would induce

and Zilberfarb (1993), who find that there is a threshold effect by which uncertainty increases with inflation in high inflation episodes, and this link is weaker at low inflation.

⁹See Lach and Tsiddon (1992) and references therein.

an increase in investment. However, the recent literature on irreversible investment has shown how this relationship can be reversed.¹⁰ The fact that investment is irreversible, that is roughly once a machine has been put in place it has no alternative use (and therefore no resale value), implies an additional opportunity cost of investment stemming from value of waiting while new information is revealed, which is called the option value of investment. When investment is irreversible it can be considered equivalent to exercising a call option. A call option, as well as an irreversible investment project, can be exercised, but once it is exercised it has no value.

When investment is irreversible firms will not invest until the marginal cost of capital is equal to its marginal profitability but they will require additional profitability to compensate for bad shocks in which case they could end up with too much capital. Now we can analyze what happens with an increase in uncertainty. Consider a project that has a random return. When uncertainty increases it is more likely that there will be more good and bad outcomes in the future. However only bad outcomes matters since it is more likely that the investment project turns out to be unprofitable. In contrast, good outcomes will only reassure that the investment has been profitable, without altering the firm's decision. This is what Bernanke (1983) has called the "bad news principle of irreversible investments," i.e. "that of possible future outcomes, only unfavorable ones have a bearing on the current propensity to undertake a given project." This has led many economists to conclude that the irreversible investment literature provides strong support to the idea that uncertainty is harmful for investment and growth. However, this conclusion is not general. As stressed by Caballero (1993), although an increase in uncertainty increases the required return, the increase in uncertainty also implies that extreme realizations of the return on investment will be more likely to occur, and therefore, the net effect on investment is ambiguous. A way to insure that uncertainty reduces investment is to assume that investors have some degree of risk aversion, which adds new costs to increased uncertainty.

Finally, Aizenman and Marion (1993) have emphasized the different impact that persistence and uncertainty of policies have on economic growth. They argue that is the interaction between persistence and uncertainty what may be harmful for growth.

¹⁰See Bernanke (1983), McDonald and Siegel (1986), Dixit and Pindyck (1993), and Bertola and Caballero (1994).

The higher the persistence, that is the more likely a bad outcome will remain in the future, the higher is the impact of uncertainty on investment since the decline in the present value of investment caused by a bad shock is higher the higher is its persistence. Thus, according to the bad news principle the more persistent the policy the higher the effects of uncertainty on investment and growth.

2.4 Financial market distortions

Recent research has focused on the links between financial markets and economic growth (e.g., King and Levine, 1993). However, an area that has received less attention but seems to be well-known by policymakers are the effects of inflation on the operation of financial markets. Thus, if inflation reduces the ability of financial markets to perform efficient financial intermediation, this will constitute an additional channel through which inflation may be harmful for growth. This issue was stressed in the development context by McKinnon (1973) and Shaw (1973) who argue in favor of a stable price level for developing countries in order to induce financial intermediation, in particular the development of long term contracts.

Most of the recent literature on this topic emphasizes the fact that in world of imperfect information, the informational problems may be exacerbated at high inflation rates. affecting the efficiency with which credit is allocated, and the total volume of intermediation. Azariadis and Smith (1993) present a model where households can hold deposits, which are subject to inflation tax and are intermediated by banks, or alternatively, they can hold unintermediated assets (e.g., storage). There are also two types of borrowers, those who use credit to produce capital goods ("legitimate") and those who obtain credit, convert it in storage and do not repay ("illegitimate"). To avoid the adverse selection problems banks offer contracts such that "illegitimate" borrowers have no incentives to misrepresent their type. When they are detected, they work and become depositors. However, as inflation rises the incentives to hold deposits decline, and hence, inducing full revelation requires to penalize more to legitimate borrowers, so illegitimate ones have no incentives to misrepresent their type. Within this framework Azariadis and Smith (1993) conclude that at low rates of inflation the Mundell-Tobin effect holds since there is no problems of misrepresentation. However, at high inflation rates the tightened restrictions to induce full revelation

reduce capital accumulation of legitimate borrowers and the Mundell-Tobin effect is reverted.

McKinnon (1991) argues that moral hazard problems in the banking sector also increase with inflation. The moral hazard problem stems from the fact that banks may get involved in highly risky lending—such as that in Argentina and Chile in the 1970s—when they perceive that losses will be covered by the monetary authorities. In contrast they receive the full benefits of favorable outcomes. In a stable macroeconomic environment there is no covariance in the probability of default across projects. However, macroeconomic instability induces high covariance in default rates, which coupled with poor financial regulation will induce banks to increase their interest rates, lending to more risky projects (as in Stiglitz and Weiss 1981) and increasing the overall fragility of the financial system.

Finally, De Gregorio and Sturzenegger (1994) also stress the informational problems induced by inflation in the operation of financial markets. They present a model with two types of firms. One type is less productive and has a positive probability of default, while the other is more productive and does not default. A central element of the model is that inflation increases the similarity between the two types of firms. This could occur because the productivity of safe firms declines with inflation, or, due to higher search costs, the demand faced by low-productivity firms increases relative to that of high-productivity firms. When inflation is low, a fully revealing equilibrium prevails, in which banks can perfectly identify each type of firm. However, as inflation rises, low-productivity firms have more incentives to appear like high-productivity firms since the costs of mimicking their behavior declines. At the same time, high-productivity firms have less incentives to signal their type, since signaling costs increase with inflation. Thus, high inflation may induce a pooling equilibrium in which banks are unable to distinguish between the two types of firms, lending more to low-productivity firms and less to high-productivity firms than in a fully revealing equilibrium.

3 On the Sources of Inflation and the Role of the Central Bank

To study the sources of inflation, there are mainly two (complementary) approaches. The first approach analyzes inflation in the context of public finance, where inflation is related to the financing of the budget. The second approach considers inflation as an instrument that is used to exploit a short-run trade-off between inflation and unemployment in order to reduce macroeconomic fluctuations. This section integrates both approaches and discusses the role of a central bank in controlling inflation and whether it may contribute positively to overall economic performance.¹¹

3.1 The case for an independent central bank

In the short run inflation surprises induce booms in output. This is the underlying assumption in the modern versions of the Phillips curve, in which, due to price stickiness or informational problems, an unanticipated inflationary shock reduces real wages and expands output and employment beyond their full employment level.

Governments, in turn, may have an output target above full employment because the full employment level of output, because the latter may be considered to be too low. This may happen, for example, because the existence of distortionary taxes reduces equilibrium output, or because monopoly power in goods and labor markets induces under-production. Therefore, the government may have an incentive to create inflation surprises to drive output to its desired level. However, in a world of rational expectations private agents will realize about these intentions, and hence, these incentives will be taken into account by the private sector when setting inflationary expectations and negotiating wages, so—unless the government has superior information—inflationary surprises cannot occur. This is the key insight from the seminal work by Kydland and Prescott (1977) and Barro and Gordon (1983). This framework can be used to understand why there is inflation and how an independent central bank may help to achieve lower inflation.

To explain the main insights from this theory I present a summarized version of Barro and Gordon (1983). Suppose that a policymaker dislikes inflation (π) and

¹¹For further discussions on central bank independence see Cukierman (1992) and Walsh (1993).

deviations of output from its desired level. The target level of output is $y^* + \tau$, where y^* is output when unemployment is at its natural rate (or also called the noninflationary rate) and τ is a distortionary tax, which reduces full employment output below the socially optimum. The loss function of the government is:

$$L = \frac{\pi^2}{2} + \frac{\delta}{2}(y - y^* - \tau)^2, \quad (3)$$

where the parameter δ represents the relative aversion to output deviations with respect to inflation. A low value of δ represents low tolerance to inflation, and hence $1/\delta$ may be called inflation aversion.

The level of output is determined by the following Phillips curve:

$$y - y^* = \pi - \pi^e \quad (4)$$

where π^e is expected inflation, and for simplicity the slope of the Phillips curve can be set equal to one.

The government decides π taking π^e as given. Solving the optimization problem of the government (minimization of (3) subject to (4)) it can be shown that the optimal action of the government, given π^e , is:

$$\pi = \frac{\delta}{1 + \delta}(\pi^e + \tau)$$

Note that the higher the distortion (τ) the higher is the rate of inflation the government wants to implement to produce an expansion of output. On the other hand, the higher is π^e the higher is π to induce output above full employment. However, the private sector cannot be surprised since there is no uncertainty. Therefore, in equilibrium $\pi^e = \pi$. This implies that the equilibrium rate of inflation is:

$$\pi = \delta\tau$$

and consequently $y = y^*$.

In equilibrium, there is positive inflation and output is not different from y^* . This is the basic *time consistency problem*, by which the fact that the government attempts to create inflation surprises brings on inflation large enough to discourage the government from engineering inflation surprises. The loss would be lower if inflation were set at zero, because $y = y^*$ anyway. However, zero inflation cannot be sustained in equilibrium. If the private sector sets $\pi^e = 0$, the government would set $\pi = \delta\tau/(1 + \delta)$, generating an output boom, and hence it would be irrational to set $\pi^e = 0$.

Although (3) may represent society's preferences, it may be beneficial to achieve lower inflation. Here is where a conservative central banker as proposed by Rogoff (1985) may be a good solution to the time consistency problem. If δ in (3) is substituted by $\delta' < \delta$, the inflation rate would be lower, while output would be the same. In the limit, a central banker that does not care about output ($\delta' = 0$) would produce zero inflation. The important lesson from this analysis is that society may benefit from having a central bank with inflation aversion greater than $1/\delta$.

This constitutes one of the basis for proposals of central bank independence with a clear mandate to price stability. Although many central banks also have as objective the achievement of output stability, the price stability objective (reinforced beyond society's tolerance for inflation) would be the key to low inflation.

However, central bank independence is not without costs. As Rogoff (1985) shows, central bank independence may result in excessive output fluctuations. The framework presented here cannot address this issue since output is always at its full employment level. However, one could add a shock to the Phillips curve, by which output could fluctuate around its full employment level. For example, at the right hand side of equation (4) a shock ϵ could be added. This shock could be, for example, a terms of trade or a productivity shock. The shock ϵ is not observed by individuals when setting expectations, and only the government can observe it before setting policy. Therefore, inflation could be used to offset the shock. For example, a positive inflationary surprise when ϵ is negative could offset the recessionary impact of ϵ . The reaction to the shock by a central bank with low δ' will be too conservative, and, as a consequence, to achieve low inflation there may be an insufficient reaction to a bad realization of ϵ . Thus, the design of an independent central bank will involve a tradeoff between stability and flexibility. Several mechanisms have been analyzed in the literature to choose a socially acceptable combination between flexibility and stability (Rogoff, 1985; Canzoneri, 1985; Lohmann, 1992; and Garfinkel and Oh, 1993). Alternatively, some recent work by Persson and Tabellini (1993) and Walsh (1995) have analyzed the problem of designing an independent central bank from a principal-agent framework. They focus on the optimal contract with the central bank. They discuss the role of imposing penalties on the central bank conditional on the state of the economy, or the role of central bank announcements when penalties cannot be

implemented.¹²

Recently, Alesina and Gatti (1995) have argued that although a conservative central banker may not offset enough “economic uncertainty,” as that envisioned by Rogoff (1985), they may reduce “political uncertainty.” The reason is that in a model such as that of Alesina (1987), the political cycle may induce business cycle because of the uncertainty about election outcomes. An independent central bank, insulated from political pressures, may reduce the uncertainty about the future course of monetary policy when there is a change in government. The overall effect will depend on the relative importance of “political” versus “economic” uncertainty. Alesina and Gatti (1995) have stressed that political considerations may explain why the evidence (reviewed below) suggests that independent central banks bring low inflation at no real costs.

In Latin American economies, and more in general in high inflation countries, it is difficult to think that the source of inflation are attempts of the government create inflation surprises in order to boost output. Indeed, most analysts would argue that at the heart of the inflationary problem there is a fiscal problem.¹³ Therefore, it is important to analyze the role of fiscal imbalance on the sources of inflation and the role of central banks. This is the issue addressed in the next section.

3.2 Fiscal policy considerations

In the real world the game played to determine inflation is more complicated. A relevant complication is to include a fiscal authority whose objectives are to finance government spending with a combination of taxes and inflation. I adapt a model due to Alesina and Tabellini (1987), later used by Debelle (1993) and Debelle and Fischer (1994), to discuss the interactions among the monetary and fiscal authorities and the private sector.

Consider now that society also values government spending (g) to be around an optimal level g^* , so the loss functions is:

$$L = \frac{\pi^2}{2} + \frac{\delta}{2}(y - y^* - \tau)^2 + \frac{\rho}{2}(g - g^*)^2 \quad (5)$$

¹²For reasons of space I will not discuss the contract-theory approach to central banking. For further details see Fischer (1995).

¹³See, e.g., Dornbusch and Fischer (1993) and Végh (1993).

Output is still determined according to equation (4). Government spending is financed through taxes and inflation, that is:

$$g = \pi + \tau. \quad (6)$$

I will discuss two different institutional arrangements: the centralized case (superscript C), in which the fiscal and the monetary authority are the same, and the decentralized (superscript D) case, in which the central bank is independent and therefore, the fiscal and the monetary authority are separated.

The *centralized* solution considers the fiscal and the monetary authority to be the same. The policymaker chooses both inflation and taxes to minimize (5) subject to the Phillips curve and the budget constraint (6). Solving this problem it is easy to show that the centralized solution is given by:

$$\begin{aligned} \pi^C &= \frac{2\delta\rho}{\delta(1+\rho) + \rho(1+\delta)} g^*, \\ \tau^C &= \frac{\rho}{\delta(1+\rho) + \rho(1+\delta)} g^*, \\ g^* - g^C &= \frac{\rho}{\delta(1+\rho) + \rho(1+\delta)} g^*. \end{aligned}$$

This solution indicates that inflation is positive, so it is above the optimal of zero inflation, and output and government spending are below their targets. Again there is a time consistency problem, by which inflation is higher than what would be if the government were able to commit to low inflation. Since there is a need to finance the budget, the optimal level of inflation and taxes are positive. But, in the centralized solution inflation is still too high.

In the *decentralized* arrangement I assume, for simplicity, that the fiscal authority cares only about inflation and government spending (not output) with the same weights as society, and the monetary authority cares only about inflation and output (not g). The fiscal authority chooses τ , taking π and hence g as given, and the monetary authority chooses π subject to the Phillips curve, taking also τ and hence g as given. The choices are made simultaneously.¹⁴

¹⁴The problem can be solved more general by assuming that both policymakers have the same loss function (5). The difference is that the fiscal authority chooses τ and the central bank π . The results are more complicated, but the implications are qualitatively the same.

The solution to the decentralized arrangement is the following:

$$\begin{aligned}\pi^D &= \frac{\rho}{\delta(1+\rho) + \rho} g^* \\ \tau^D &= \frac{\delta\rho}{\delta(1+\rho) + \rho} g^* \\ g^* - g^D &= \frac{\delta}{\delta(1+\rho) + \rho} g^*.\end{aligned}$$

The characteristics of the solution are similar to those of the centralized case, that is all of the variables are away from their target. More interesting, however, is that the following results can be established (after some tedious manipulations):

- $\pi^C > \pi^D$, $\tau^C < \tau^D$, and $g^C > g^D$. That is, with an independent central bank the fiscal authority must rely more heavily on taxes to finance the budget than on inflation to finance the budget. Moreover, the existence of an independent central bank imposes some discipline on the spending side too since the resulting level of government spending declines.
- Welfare in the decentralized case is higher than welfare in the centralized case. Moreover, with central bank independence, welfare increases if inflation aversion, $1/\delta$, increases.

The first result highlights the discipline effects that an independent central bank. An independent monetary authority reduces the time consistency problem, producing less inflation. The strong result is the second one, by which welfare is higher in the decentralized case. Moreover, shifting to a more conservative central banker, with $\delta' < \delta$, also increases welfare. It has to be recalled, however, that this statement refers only to values close to δ , and it is not necessarily true that welfare will be maximum with a central bank completely inflation averse ($\delta' = 0$).

The model could be extended to consider other important issues on the sources of inflation and the role of an independent central bank. First, one important reason why do countries rely on inflation to finance the budget is that their tax system is inefficient, so a less costly way to raise revenue is through inflation tax. In terms of the model, one could think of the budget constraints of the government as being $g = \phi\tau + \pi$, where $1 - \phi$ represents the fraction of taxes that are lost due to inefficiencies.

✦ The inefficiencies may be that tax evasion is high or simply that the tax system is

poorly administered. But, in general, the fiscal authority has some control over ϕ , and hence an independent central bank may induce the government to increase tax compliance.¹⁵

Second, an important aspect where the decentralization of fiscal and monetary authority may help is in the case that the government spending target is above the social optimum. The political system as well as electoral considerations exert strong pressures on expansions of government spending. Thus, one could think that the government's utility function has a target \bar{g} , that is greater than the social optimum g^* . The previous analysis suggests that an independent central bank will be more beneficial in these circumstances, by inducing lower government spending than the centralized solution.

In summary the previous discussion suggests that an independent central bank may be helpful in achieving price stability. Not only reduces time consistency problems, but also imposes constraint on the fiscal authority that help to achieve a more beneficial mix of taxes and level of government spending. This is particularly important in economies where the fiscal position is weak since the inability to set the inflation tax induces fiscal discipline. One of the main goals of an independent central bank is price stability, and perhaps, it should weigh inflation more than what society is willing to tolerate. However, the analysis also suggests that a central bank with extreme inflation aversion may be harmful. It may depress excessively government spending and allow excessive output fluctuations. As I discuss later, these two aspects may have negative impact on long-run growth.

4 Empirical Evidence

This section reviews and complements existing empirical evidence on the relationship between inflation and growth, and on the effects of central bank independence (CBI) on inflation and growth. As shown by Levine and Renelt (1992) many of the variables found in the literature as significant determinants of economic growth are not robust to the conditioning information, in the sense that their statistical significance depends on which variables are included or excluded from the regressions. In particular, they

¹⁵Cukierman, Edwards and Tabellini (1992) argue that inefficiencies in the tax system may result from political and distributional conflicts in the economy.

find that inflation is not robust. Although these findings suggest to be cautious when interpreting results from cross-country regressions—specially when they are estimations of loosely specified reduced forms—it does not necessarily imply that a certain (non-robust) variable does not affect growth. This may also be the consequence of high degree of correlation among independent variables, what makes difficult to disentangle the individual effect of each variable. This section indeed shows that the negative correlation between inflation and growth appears to be robust to several changes in specification, which is confirmed by most, but of course not all, of the work reviewed here.

4.1 Inflation and Growth

The early empirical work on inflation and growth focused on estimating Phillips curve-type relationships, and hence, it used high frequency data to capture the short-run tradeoff between inflation and growth. Fischer (1983) shows, in a panel for 53 countries and yearly data for the periods 1961–73 and 1973–81, that there is a negative correlation between inflation and growth even at yearly frequency.¹⁶

In the growth literature, in turn, most of the early work was on growth accounting, which aimed to decompose the sources of growth into growth of inputs and factor productivity growth. It was not until Kormendi and Meguire (1985) that macroeconomic factors were incorporated as determinants of long-run growth in cross-section analysis for relatively long periods of time (1950–77). The basic regression they run, and that has been basically the same in later work, is:

$$\gamma = \beta_1 X + \beta_2 Y_0 + \epsilon \quad (7)$$

where γ is the rate of growth, X is a set of independent variables, Y_0 is the initial level of per-capita GDP, and ϵ is the error term. The rationale to include Y_0 is to control for convergence of income across countries. It has been widely documented (see Barro and Sala-i-Martin, 1992) that after controlling for variables that explain differences in steady state output across countries (X), economies with lower GDP per capita grow faster than richer ones.

An important aspect of estimating (7) is whether the rate of investment should

¹⁶For another review of the evidence with additional references on time series studies see Briault (1995).

or should not be included in X . This is of course a difficult issue which goes beyond the scope of this paper, but in terms of interpreting the evidence it is useful to make the distinction.¹⁷ If investment rates are not included, the effect of a variable in X on growth can be interpreted as the effect of that variable on growth by increasing both the rate of investment and the efficiency of investment (see equation (2)). On the other hand, when the rate of investment is included in the regression, the effect of inflation on growth is only due to increased efficiency of investment. Another alternative that can be used to separate the investment and the efficiency channels is to run a regression like (7), but with investment as the dependent variable.

Kormendi and Meguire (1985) include among the X variables the average change in the rate of inflation with respect to the initial year, and concluded that a deceleration of inflation by 2 percent a year could increase the rate of growth by about 1 percentage point (p. 150). When they add investment as a dependent variable the coefficient on inflation declines to about half of its original value, which suggests that high inflation reduces growth by reducing, roughly in equal proportions, both the rate of investment and its efficiency. Nevertheless, this finding is not easy to interpret since it is the change, rather than the level, of inflation what is being used as independent variable. Later on, Grier and Tullock (1989) extend the sample to cover 1951–80 and use five-year average panel data. They conclude that inflation has no effects on growth in OECD countries, but in the rest of the world there is a negative and significant impact of inflation on growth. The coefficient found for non-OECD countries seems to be, however, surprisingly high, since it suggests that an increase of 10 percentage points in inflation may reduce the rate of growth by 1.6 percentage points.

Similar results have been obtained by Fischer (1991) for a sample of 73 countries during the period 1970–85. When investment is included (regression (5)) it is found that a 10 percent inflation rate would reduce growth by 0.5 percentage points, which corresponds to the efficiency channel. In addition, Fischer (1991) finds that 10 percent inflation reduces investment by 1.5 percentage points (regressions (9) to (11)).¹⁸ Taken these results together it can be conclude that 10 percent inflation reduces growth by about 0.7 percentage points, of which 0.5 are due to the efficiency

¹⁷See Blomström, Lipsey and Zejan (1993) and Barro and Sala-i-Martin (1995, p. 433) for further discussions on this issue.

¹⁸In addition, regression (5) shows that each percentage point of investment rises growth by 0.11 percentage points.

channel and 0.2 to the investment channel. Roubini and Sala-i-Martin (1992) using the dataset and the specification of Barro (1991), which does not include investment as a regressor, find that 10 percent inflation reduces growth by 0.5 percentage points. They show that the continental dummies used by Barro (1991) are reduced substantially when inflation is included, arguing that an important explanation for the poor growth performance of Latin America and Africa is their high inflation rates. Easterly (1994) finds quantitatively similar results (10 percent inflation reduces growth by 0.4 percentage points), but he argues that the result is not robust to the inclusion of other policy variables.

Fischer (1993) extends the previous results analyzing a wide variety of indicators of macroeconomic policy. Regarding inflation he finds that an inflation rate of 10 percent induces a total decline in the rate of growth of 0.3 percentage points (regression (39)). Based on his estimates for the rate of growth of capital, and assuming that the capital-output ratio is 2.5, it can be concluded that 10 percent inflation reduces investment by 0.8 percentage points, which in terms of growth would be around 0.1 percentage points. Therefore, only one third of the effects of inflation on growth would be through the investment channel.¹⁹

An important handicap of the empirical analysis on inflation and growth is the endogeneity of inflation. Consider, for example, an economy that is hit by a negative supply shock. This shock would reduce output, but also would result in an increase in inflation, and hence, the coefficient on inflation cannot be interpreted as the effects of inflation on growth. Similarly, consider a central bank that follows a constant money growth policy. A negative shock to the rate of growth would increase the rate of inflation, and hence the causality would go from growth to inflation. Cukierman, Kalaitzidakis, Summers and Webb (1993) address this issue by using indices of central bank independence (discussed in more detail in the next subsection) as instruments for the rate of inflation. They conclude that there is still a negative relationship, although statistically not as strong as that found in OLS regressions. However, the point estimate in their OLS regression implies that 10 percent inflation

¹⁹Fischer (1993) separates the effects of inflation on its effects on factor accumulation and productivity growth, which is slightly different to the distinction between investment and efficiency of investment, the difference being the capital-output ratio. He finds (table 9) that 10 percent inflation reduces capital accumulation by 0.3 percentage points, which implies (with a share of capital equal to 0.4) that the capital accumulation effect explains about 0.12 of the 0.3 reduction of growth, and the remaining is explained by the reduction in total factor productivity growth.

reduces growth by 0.2 percentage points, but in their favorite instrumental variables regression (regression (4) in table 6) this effect increases to 0.5 percentage points, similar to previous studies.

Using a panel of 122 countries for the three decades from 1960 to 1990, Barro (1995) analyzes the impact of inflation on growth running the standard regressions and using instruments. The instruments used are lagged inflation, and, alternatively, prior colonial status, which is found to be highly correlated with inflation, because, for example, former French colonies in Africa have been in the CFA franc zone. Indices of central bank independence are found not to be good instruments. He finds also that a reduction of 10 percentage points in the rate of inflation would increase the rate of growth by 0.2 to 0.3 percentage points, while it would increase the investment rate by 0.4 to 0.6 percentage. The coefficients on inflation in the investment equations are only significant in the regressions that instrument inflation. Assuming the usual estimate of the effects of investment on growth (0.1), it can be concluded that a ten percentage points reduction in inflation increase growth by 0.2 or 0.3 out of which roughly 0.05 are due to the investment channel.

Another aspect of the relationship between inflation and growth is the possibility of nonlinearities. Levine and Zervos (1993) confirm Levine and Renelt (1992) findings that inflation is not a robust determinant of long-run growth. The former paper analyzes the possibilities of nonlinearities by distinguishing between high and low inflation and find that results are strongly influenced by some outliers. Fischer (1993) also separates inflation in low (less than 15 percent), medium (15 to 40) and high (above 40), and finds that the coefficient is declining when going from low to high inflation. This is not surprising, since increasing inflation from 10 to 20 percent should be more damaging for growth than going from 180 to 190 percent. This suggests that inflation should enter nonlinearly in the regression, such as the log of inflation or other transformation that reduces the impact of high inflation rates. Indeed, De Gregorio (1993) finds that the coefficient is more stable across different inflationary regimes when inflation is introduced in log form.

The issue about non linearities of the relationship between inflation and growth has been carefully explored in Sarel (1995). He estimates a regression such as (7), with inflation in a log form. Sarel argues that omitting this break could induce an underestimation of the effects of inflation on growth. The results show that there is

a break at an inflation rate of 8%. Above that break the effect of inflation on growth is significant, robust and quite large. For inflation below 8% it is found that it does not have effects on growth, and at most, a small positive effect. The coefficient found when this break is considered indicates that doubling the rate of inflation will reduce the rate of growth by 1.7 percentage points. When the break is not considered the effect declines to a third. However, and as it is argued below, low-inflation countries include OECD countries and several low-growth African countries. Therefore, this combination is what may downplay the effects of low inflation on growth. When industrialized countries are considered separately, there is still a negative correlation between inflation and growth.

Another study looking at nonlinearities is Bruno and Easterly (1995), who use a nonparametric approach to study the effects of high inflation ("inflation crises"), above 40%, and growth, conclude that inflation crises lead to sharp reductions in growth, and recovers strongly after stabilization. Moreover, these results support the view that stabilizing high inflation does not entail output losses.

Latin America has been the region with the highest inflation rates, and where we could expect to find the stronger effects. Indeed, Cardoso and Fishlow (1991) examine the correlation between inflation and growth and find that a reduction of inflation of 20 percent would increase growth by 0.4 percentage points. De Gregorio (1992, 1993), estimating regressions as (7) for a panel data of 12 Latin American countries during the 1950-85 period, finds that reducing the rate of inflation by a half increases GDP per capita growth by 0.4 percent. This magnitude is sizable if we consider that average rate of per capita growth in the sample is 1.3 percent per year and the average rate of inflation is 34 percent.²⁰ In addition, De Gregorio (1993) finds that inflation has no effects on investment, concluding that inflation affects the productivity of investment rather than its level. Cardoso (1994) also finds weak evidence for the correlation between investment and an index of economic instability constructed on the basis of the debt ratio, the rate of inflation and the variability of the real exchange rate.

There is some evidence, however, that reports a negative relationship between investment and inflation. Pindyck and Solimano (1993) report a statistically significant

²⁰The results are similar for the average inflation rate, the variance of inflation and the rate of money growth.

relationship between investment and inflation for a sample of high inflation countries (Argentina, Bolivia, Brazil, Chile, Israel and Mexico) but the value of the coefficient is very small. The highest coefficient they find is -0.00016, which implies that a going from zero to 1000 percent inflation per year would reduce investment by only 0.2 percentage points. They find, however, an economically significant effect in a sample of OECD countries, where a 10 percent inflation would reduce total investment by 0.9 percentage points.²¹ Corbo and Rojas (1993) find that Latin American countries with inflation above 50 percent have 1.3 percentage points of lower investment than those countries with low inflation. Their coefficients are, however, only marginally significant. They also run separately equations for growth and investment and find that reducing inflation by 10 percentage points increases both growth and the rate of investment by 1 percentage point. Therefore, their results confirm that most of the effects of inflation on growth are due to a decline in efficiency.

There are some studies that do not find robust effects of inflation on growth. As already mentioned, Levine and Zervos (1993), using World Bank data on output growth, find that the relationship is not robust. Moreover, they argue that Nicaragua and Uganda are two outliers that change dramatically the results. McClandess and Weber (1994) examining the partial correlations between inflation and growth in a sample of 110 countries, with all data taken from IFS for the period 1960–90, find that they are not correlated. One explanation for the lack of correlation of some studies offered by Bruno and Easterly (1995) is that the declining path of growth during inflation crises is offset by the strong recovery after stabilization.

In the remaining of this section I complement the empirical evidence reviewed previously. Figures 1 and 2 present simple cross-section correlations of inflation, and growth and investment, respectively. The figures show that there is indeed a negative correlation between inflation and growth, and a weaker negative correlation between inflation and investment. In tables 1 and 2 I present cross-country regressions for inflation and growth. I use the data from Barro (1991) and completed them with inflation from IFS. Based on the previous discussion I use the log of the inflation rate. Following Levine and Zervos (1993) I exclude Nicaragua and Uganda from the sample.²² There is some evidence of heteroscedasticity, thus the standard deviations

²¹This is of the order of magnitude of the findings of Fischer (1991, 1993).

²²In addition I experimented with the log of 1+inflation and the results do not change significantly.

are computed using White's robust procedure.

Regression 1.1 show that there is a significant negative correlation between inflation and growth, after controlling for the traditional variables. Since the dependent variable is the log of inflation, the parameter implies that reducing inflation by 10 percent (not percentage points) would increase growth by 0.06 percent. That is, reducing inflation to half of its value (the average inflation rate is 15 percent) would increase growth by 0.4 $[-0.057 \times \log(0.5)]$ percentage points.²³ If the regression were run with linear inflation the effect of inflation would still be significant, but weaker, since a reduction of inflation by 10 percent would increase growth by 0.2 percentage points. Regression 1.2 separates inflation in high and low inflation, using 20 percent as a cutoff. The results show a similar coefficient and they indicate that is high inflation what is harmful for growth.

In contrast to the regressions that separate the sample between high- and low-inflation countries, when the equation is constrained for a sample of industrialized countries (regression 1.5) the negative effect of inflation and growth remains strong, and the coefficient declines only slightly. This apparent contradiction may be explained by the interactions of inflation with the other explanatory variables. But mainly, this is due to the fact that low-inflation combines low-inflation and low-growth African countries with moderate-growth and low-inflation industrialized countries. Finally, the effect of inflation on growth in developing countries appears to be stronger (regression 1.6).

Regressions 1.3 and 1.4 reproduce the first ones with the addition of the rate of investment as dependent variable. The coefficient on investment is significant, but the inclusion of this variable does not change significantly the coefficients on inflation. According to the results, at least three quarters of the effects of inflation on growth is through the efficiency channel.

In table 2 I check the robustness of the results. First, I do not use White's correction, despite the evidence of heteroscedasticity, since I found that the t-statistics tend in general to experience a slight increase, and thus, I use the approach most negative for the robustness of inflation. Second, I add the index of number of revolutions and coups per year from Barro (1991), since it appears also to reduce the

²³In De Gregorio (1993) the coefficient is -0.008 and in Sarel (1995) -0.025 when the break is considered and -0.008 otherwise.

strength of the effects of inflation.²⁴ And third, I exclude Argentina, Bolivia, and Peru, three countries that have had high inflation rates and poor growth performance and could be driving the result in the sample of developing countries. The results show the revolutions and coups reduces by almost a quarter the effects of inflation in growth. More interesting is the fact that the exclusion of Argentina, Bolivia, and Peru increases the value and the significance of the coefficients in the full sample and in developing countries.²⁵

The investment channel is further explored in table 3. The regressions use the same regressors as in the case of the growth rates. It is interesting to verify that in all specification inflation is not significant. Several other experiments were performed, such as excluding the variables that were not significant, splitting the sample between low and high inflation, adding growth and political variables as regressors, etc. The only regression where I found a significant coefficient was when investment in low inflation countries was run with inflation as the only regressor. The coefficient was -0.07 and the t-statistic -2.8, but once indicators of schooling or the initial GDP were added the coefficient on inflation became insignificant. This coefficient is similar to that found in other studies. The results suggest that the difference with other studies that have found a significant coefficient of inflation on investment equations is that they do not include variables like the initial level of human capital or the initial level of output.

The result reported in this paper suggest that inflation have negative effects on growth. This effect holds for a subsample of low-inflation industrialized countries. When analyzing developing countries separately the results indicate that is high inflation what matters for growth. Finally, most of the effect of inflation on growth are through the efficiency channel.

4.2 Central bank independence and macroeconomic performance

As discussed in the previous section theory predicts that the more independent (and inflation averse) is a central bank the lower the inflation rate will be. Furthermore, if low inflation rates lead to faster growth, one should expect a negative association

²⁴Other indices of political instability were added to the regressions, but the only significant one was the index of revolutions and coups.

²⁵In regressions 2.1 and 2.5 the use of White's correction would make inflation to be significant at 5 percent level.

between central bank independence and a positive one between CBI and growth. I begin by reviewing the evidence on CBI and inflation and growth for OECD countries, which has been the focus of most of the existing empirical studies, and then I review the evidence for developing countries.

The first issue that must be addressed is how to measure CBI. Many authors have tackled this difficult task, most notably Bade and Parkin (1982), Alesina (1988), Grilli, Masciandano and Tabellini (1991) [GMT], Cukierman (1992), Cukierman, Webb and Neyapti (1992) [CWN], and Alesina and Summers (1993) [AS]. These studies, with the addition of De Long and Summers (1992), and Cukierman, Kalaitzidakis, Summers and Webb (1993) have analyzed the relationship between CBI and macroeconomic performance.

CBI can be measured by evaluating the extent to which the law gives the central bank independence to set the policy objectives. This is what has been broadly called “political” or “legal” independence and consists in examining the influence of the government in appointing the governor and the board, the length of the appointments, the final objectives of the central bank, and other legal characteristics stated in central banks’ charters. Most of the measures of legal and political independence has been constructed for industrialized countries.

Another aspect of CBI, emphasized first by GMT, is the “economic” independence of the central bank. This is defined as the independence of the central bank in choosing monetary policy instruments. In particular, the influence of the government on how much to borrow from the central bank, for example whether the government has an automatic credit facility and whether it is at market interest rates. Economic independence is also defined in terms of the instruments under control of the central bank, such as control on the discount rate or banking supervision.

Table 4 presents the most widely used indices of CBI, the inflation rate during the period 1960–85, and the rate of growth of per capita GDP for the same period for a sample of OECD countries. The GMTAS index is the sum of the economic and political independence indices constructed by GMT and later extended by AS. The other index corresponds to the legal index constructed by CWN as reported in Cukierman (1992, table 19.3). Both measures are highly correlated, except for the cases of Norway and Japan, which according to CWN have low legal independence, while the GMTAS index puts them around the mean.

Figures 3 and 4 replicate the negative correlation between both measures of CBI and inflation found in most of previous studies. This relationship appears to be robust to changes in the specification as well as alternative measures of CBI.

The relationship between CBI and growth is less clear. Figure 3 plots the rate of GDP per capita growth and the GMTAS index of CBI. As can be seen from the figure there is basically no relationship between growth and CBI. However, as shown by De Long and Summers (1992), once rates of growth are controlled by initial GDP, there is a positive relationship between growth and CBI. Figure 4 uses the partial scatterplot proposed by De Long and Summers (1992). The vertical axis measures the residual from a regression of the rate of growth on GDP per capita in 1960, that is, the component of growth that is not explained by convergence. Similarly, the horizontal axis measures the orthogonal component of CBI on initial GDP. The figure shows a positive correlation between CBI and growth. The underlying regression is the following:

$$\begin{array}{ccccccc} \text{Growth} & = & 6.58 & - & 2.907 \log GDP60 & + & 0.344 CBI \\ & & (9.62) & & (-6.19) & & (1.86) \end{array} \quad (8)$$

$R^2 = 0.75$, N obs. = 16, and t-statistics in parenthesis.

It is important to note, however, that the coefficient on growth is marginally significant, and it is difficult to make a strong case for a positive and robust correlation between CBI and growth. The results are also sensitive to the classification of Japan. A similar result has been found by Cukierman, Kalaitzidakis, Summers and Webb (1993), who find that CBI has no significant effect on growth in industrialized countries.

Several reasons can explain the lack of (or the weak) correlation between growth and CBI. First, at low levels of inflation, such as those of industrialized countries, inflation may have little effects on growth, and hence, an independent central bank may have limited role in fostering growth. Second, the low inflation record may be at the expense of high output variability, which may be harmful for growth.

Nevertheless, the evidence suggests that, in contrast to the theoretical predictions, CBI is uncorrelated with output variability. Models such as Rogoff (1985) predicts that an independent central bank produces less inflation, but at the cost of higher variability of output. The fact that CBI leads to lower inflation without costs in terms

of output growth or instability has led to GMT to argue that “having an independent central bank is like having a free lunch; there are benefits but no apparent costs in terms of macroeconomic performance.”

DeBelle and Fischer (1994) have revisited this issue, and conclude—by comparing US and Germany, and then extending the analysis to a group of OECD countries—that countries with more independent central banks tend to have greater output losses during disinflations and their sacrifice ratios (output loss per percentage point of inflation reduction) are larger. Walsh (1994) and Fischer (1995) have also presented evidence showing that the sacrifice ratio is higher the higher is the degree of independence of the central bank. He argues that independent central banks produce lower inflation, and, most theories predict, the lower the inflation rate the flatter the Phillips curve. Therefore, in low inflation economies it is more costly to reduce inflation. In this respect, there would not be such a free lunch and independent central banks would not have a credibility bonus that would allow them to fight inflation without increased output losses. Excessive weight in inflation prevention could be detrimental.

This evidence, however, is based on sacrifice ratios—that is the output loss associated with a reduction of *on percentage point* of inflation—, and analogously to the discussion on inflation and growth, it should not be surprising that it is less costly to reduce inflation from 10 to 9 percent than to reduce it from 3 to 2 percent. It would be more appropriate to use some form of standardized sacrifice ratios. For example, as reported by Fischer (1995), using the sacrifice ratios from Ball (1993) for 28 disinflations in OECD countries for the period 1960–90 and using the GMTAS index of central bank independence, it is found that a regression of the sacrifice ratio on the GMTAS index yield a positive coefficient with a t-statistic of 3.7. This indicates that an increase in central bank independence increases (in a statistically significant sense) the sacrifice ratio. However if the sacrifice ratio is redefined as the output loss per one percent decline in the inflation rate²⁶, the regression on the GMTAS index yields a positive coefficient, but statistically insignificant with a t-statistic of 1.17.

Furthermore, even when sacrifice ratios could be greater in countries with inde-

²⁶The usual sacrifice ratio is defined as $S = \sum_t \Delta(\bar{y} - y) / \Delta\pi$, where the numerator is the sum of output deviations from full employment, and the denominator the decline in inflation. The redefinition proposed in the text is $S' = \sum_t \Delta(\bar{y} - y) / (\Delta\pi / \pi_0)$, or analogously $S' = S \times \pi_0$.

pendent central banks, as a result of a flatter Phillips curve, it is not clear that is optimal to have zero sacrifice ratio (or vertical Phillips curve). It could be possible that precisely because the sacrifice ratio is high, the inflation rate is low. Actually, this issue boils down to what is the optimal slope of the Phillips curve in the presence of dynamic inconsistency, issue that has not been resolved.

The evidence for developing countries is more scarce, but recently Cukierman, Kalaitzidakis, Summers and Webb (1993) have provided a detailed analysis of the relationship between CBI and macroeconomic performance in developing countries. Analysis of CBI among developing countries show that indices of “legal independence” bear little relation to the actual independence of central banks. For this reason CWN have computed the rate of turnover of governors of central banks. This index seems to perform better in proxying actual independence. In developing countries the correlation between turnover rates and legal independence is very low.

An additional problem in developing countries is that inflation rates are highly variable, including several cases of extreme inflation. CWN suggest to look at $\pi/(1 + \pi)$, which corresponds to the rate of depreciation of real balance.²⁷ Figure 5 presents the simple correlation between turnover rates and inflation for a sample of developing countries. The figure shows a strong positive correlation, but it also reveals that this is to a large extent due to Argentina, the country with the highest turnover rate of central bank governors, and the highest inflation rate. One could argue that Costa Rica may be an outlier too since it has relatively low inflation and high turnover.

Table 5 presents a more formal statistical analysis between CBI and inflation. For the whole sample of countries legal independence does not significantly affects inflation. Only when the subsample of OECD countries is considered the results coincide with those of CWN that show legal independence and not turnover rates are significant determinants of inflation. In contrast, the regressions show that for developing countries turnover rates are positively associated with inflation, that is, the higher the rate of turnover the higher the rate of inflation. Several regressions analyze the case of outliers, in particular Argentina. In the whole sample, the coefficient declines from 0.37 to 0.21 but is still significant. In contrast, and contrary to CWN, the coef-

²⁷At the end of a period with inflation equal to π real value of an initial \$1 is $1/(1 + \pi)$. Thus the depreciation is $1 - 1/(1 + \pi)$. One can also look at the log of the inflation rate. For convenience I will call indistinctly inflation to both π and $\pi/(1 + \pi)$.

ficient becomes insignificant when Argentina is excluded. The last regression of table 5 shows that even when Costa Rica is also excluded the coefficient is insignificant.

Comparing the results of table 5 and those of CWN, we can conclude that an important part of the correlation they find is due to Argentina. However, the results are not exactly comparable since they run panel regressions that allow for more observations, and hence, more precise estimations. The point estimates of Table 5 are similar to those of CWN and a reasonable value for the true coefficient on turnover rates is about 0.2. This value implies that reducing the turnover rate from 0.5 to 0.25 (that is, increasing the average duration of the central bank governor from 2 to 4 years) would reduce the depreciation rate by 0.05. For an economy with 25 percent inflation, a reduction in $\pi/(1 + \pi)$ of 0.05 would be equivalent to reduce the inflation rate to 18 percent.

Regarding growth, figure 6 displays the simple correlation between growth and turnover rates. Again, this simple correlation shows that Argentina plays an important role in making the relationship negative. Regressions results reproducing tables 1 and 2 with turnover rates instead of inflation (not reported here) show no significant correlation between growth and CBI among developing countries. This result holds not only for the simple correlation, but also after controlling for initial (in 1960) primary and secondary school enrollment ratios, and per-capita GDP. The lack of correlation I find here is a direct consequence from the fact that I do not find a strong correlation between inflation and turnover rates. As in the case of inflation, the results here also contrasts with those of Cukierman, Kalaitzidakis, Summers and Webb (1993), who find a negative correlation between CBI and growth among developing countries.

5 Conclusions

This paper has reviewed the theory and evidence of inflation and growth and the role of central banks. There are many channels through which inflation affects growth and in this paper it has been emphasized the difference between the effects of inflation on the rate of investment and on the efficiency of investment. Since theory and evidence suggest that inflation is harmful for growth an effective central bank may play an important role not only in providing macroeconomic stability in the short run, but

also by its implications for long-run growth.

The theory on central bank independence suggests that the more independent and inflation-averse is a central bank the lower the rate of inflation. But, going to the extreme of a central bank that only cares about inflation is not the optimum. First, it requires to complement with the fiscal authority in setting the optimal mix of taxes. Second, and perhaps more important, a central bank with the only mandate of price stability may generate excessive output fluctuations. In the context of this paper the next natural question is what are the long-run consequences of higher output variability. This is an issue that requires further research.

The evidence on inflation and growth presented here and in other studies indicates that inflation has negative effects on growth. This evidence passes several robustness tests: it is robust across datasets, regions, endogeneity problems, etc. There are, of course, some exceptions. Quantitatively, these effects could account up to 0.4–0.5 percentage points of faster growth for a reduction of 10 percentage points in the rate of inflation.²⁸ The evidence also broadly suggests that most of the effects (at least two thirds) of inflation on growth operate through the efficiency of investment, or similarly through the rate of productivity growth. The effects of inflation on investment rates are less clear. In Latin America it is difficult to find an effect of a relevant magnitude. For larger cross-section of countries, some authors have found a negative correlation between investment and inflation, but it does not seem as robust or as strong as those found for the direct relationship between inflation and growth.

If inflation is bad for growth why is there inflation? The most accepted answer, not only by academics but also by policymakers, would be because it is costly to reduce it. Therefore, one can conclude that while there is a negative relationship between inflation and growth in the long run, this relationship is positive in the short run. There is no empirical evidence disentangling the short and long run effects of inflation, but it is puzzling that even at yearly frequencies Fischer (1983, 1993) finds a negative correlation between inflation and growth.

What do we learn from the evidence on inflation and growth with respect to the theory? The weak relationship between investment and inflation suggests that the tax imposed on investors cash holdings and the uncertainty effects of inflation on

²⁸This is valid for “average” countries, that is, with inflation rates less than 20 or 30 percent per year.

investment may not be very important. The fact that inflation affects growth mainly through the allocation (rather than the volume) of resources is not easy to explain using traditional models. As discussed in section 2, a decline in employment could explain a decline in the efficiency of investment. However, the evidence of inflation on employment is weak. De Gregorio (1993) finds no significant correlation between inflation and employment, and Fischer (1993) finds no relationship between inflation and the rate of growth of employment. Cooley and Hansen (1989), however, report a negative correlation between average inflation and employment rates for a sample of 23 countries during the period 1976–85. Nevertheless, a look at their graph suggests that this correlation may not be robust. Furthermore, Gomme (1993) calibrates a real business cycle model with endogenous growth, where employment fluctuations drive most of the results, and finds that increasing inflation, in an economy such as the U.S., by 50 percent would reduce growth by only 0.2 percent per year, which is small compared to the econometric evidence reported here. Therefore, it is necessary to explore further other channels through which inflation may have allocative effects. Perhaps, explanations along the extensions to the neoclassical model or through the functioning of credit markets (Section 2.2 and 2.4), may help to our better understanding of the relationship between inflation and growth. The literature on inflation, distributional conflicts and political factors may also provide additional insights.

The existing evidence on the affects of CBI on inflation and growth seems to suggest the following: CBI is an important determinant of inflation and its impact on growth is mostly significant in developing countries. The correlations reported here, however, suggest that those results may not be robust. The most robust result seems to be the effects of CBI on inflation among industrialized countries. The difficulties to have reliable indicators for developing countries prevent a more accurate assessment of the effects of CBI on macroeconomic performance.

References

- Abel, A. B. (1983), "Optimal Investment Under Uncertainty," *American Economic Review*, 73: 228-233.
- Aghion, P. and P. Howitt (1992), "A Model of Growth Through Creative Destruction," *Econometrica*, 60: 323-352.
- Aizenman, J. and N. P. Marion (1993), "Policy Uncertainty, Persistence, and Growth," *Review of International Economics*, 1: 145-163.
- Alesina, A. (1987), "Macroeconomic Policy in a Two-Party System as a Repeated Game," *Quarterly Journal of Economics*, 102: 651-678.
- Alesina, A. (1988), "Macroeconomics and Politics," *NBER Macroeconomics Annual*, 3: 13-52.
- Alesina, A. and R. Gatti (1995), "Independent Central bank: Low Inflation at no Cost?," *American Economic Review*, papers and proceedings, 85: 106-200.
- Alesina, A. and L. H. Summers (1993), "Central Bank Independence and Macroeconomic Performance: Some Comparative Evidence," *Journal of Money, Credit and Banking*, 25: 157-162.
- Alesina, A. and G. Tabellini (1987), "Rules and Discretion with Non-Coordinated Monetary and Fiscal Policies," *Economic Inquiry*, 25: 619-630.
- Azariadis, C. and B. Smith (1993), "Private Information, Money and Growth," unpublished manuscript, UCLA and Cornell University.
- Bade, R. and M. Parkin (1982), "Central Bank Laws and Monetary Policy," unpublished manuscript, University of Western Ontario.
- Ball, L. (1993), "What Determines the sacrifice ratio?," NBER Working Paper No. 4306.
- Ball, L. and S. G. Cecchetti (1990), "Inflation, Uncertainty at Short and Long Horizons," *Brookings Papers on Economic Activity*, 215-245.
- Barro, R.J. (1991), "Economic Growth in a Cross Section of Countries," *Quarterly Journal of Economics*, 104: 407-433.
- Barro, R.J. (1995), "Inflation and Economic Growth," *Bank of England Quarterly Bulletin*, 35: 166-176.
- Barro, R. J. and D. Gordon (1983), "A Positive Theory of Monetary Policy in a Natural Rate Model," *Journal of Political Economy*, 91: 589-610.
- Barro, R.J. and X. Sala-i-Martin (1992), "Convergence," *Journal of Political Economy*, 100: 223-251.
- Barro, R.J. and X. Sala-i-Martin (1995), *Economic Growth*, New York: McGraw-Hill.
- Baumol, W. (1990), "Entrepreneurship: Productive, Unproductive, and Destructive," *Journal of Political Economy*, 98: 893-921.

- Benàbou, R. (1988), "Search, Price Setting and Inflation," *Review of Economic Studies*, 55: 353-376.
- Bernanke, B. (1983), "Irreversibility, Uncertainty, and Cyclical Investment," *Quarterly Journal of Economics*, 98: 85-106.
- Bertola, G. and R. J. Caballero (1994), "Irreversibility and Aggregate Investment," *Review of Economic Studies*, 61: 223-246.
- Blomström, M., R.E. Lipsey, and M. Zejan (1993), "Is Fixed Investment the Key to Economic Growth," NBER Working Paper No. 4436.
- Braun, A. (1994), "Another Attempt to Quantify the benefits of Reducing Inflation," *Federal Reserve Bank of Minneapolis Quarterly Review*, 18(4): 17-25.
- Briault, C. (1995), "The Costs of Inflation," *Bank of England Quarterly Bulletin*, 35: 33-45.
- Brock, W. (1974), "Money and Growth: The Case of Long Run Perfect Foresight," *International Economic Review*, 15: 750-777.
- Bruno, M. and W. Easterly (1995), "Inflation Crises and Long-Run Growth, NBER Working Paper No. 5209.
- Caballero, R. (1993), "On the Dynamics of Aggregate Investment," in Servén, L. and A. Solimano (eds.), *Striving for Growth after Adjustment*, Washington D.C.: The World Bank.
- Canzoneri, M. (1985), Monetary Policy Games and the Role of Private Information, *American Economic Review*, 76: 1056-1070.
- Cardoso, E. (1994), Macroeconomic Environment and Capital Formation in Latin America," in Servén, L. and A. Solimano (eds.), *Striving for Growth after Adjustment*, Washington D.C.: The World Bank.
- Cardoso, E. and A. Fishlow (1989), "Latin America Economic Development: 1950-1980," NBER Working Paper No. 3161.
- Casella, A. and J. Feinstein (1990), "Economic Exchange During Hyperinflation," *Journal of Political Economy*, 98: 1-27.
- Cooley, T.F. and G.D. Hansen (1989), "The Inflation Tax in a Real Business Cycle Model," *American Economic Review*, 79: 733-748.
- Corbo, V. and P. Rojas (1993), "Investment, Macroeconomic Instability and Growth: The Latin American Experience," *Revista de Análisis Económico*, 8: 19-37.
- Cukierman, A. (1992), *Central Bank Behavior, Credibility, and Independence: Theory and Evidence*, Cambridge, Mass.: MIT Press.
- Cukierman, A., S. Edwards and G. Tabellini (1992), "Seigniorage and Political Instability," *American Economic Review*, 82: 537-555.
- Cukierman, A. , P. Kalaitzidakis, L. H. Summers and S. B. Webb (1993), "Central bank Independence, Growth, Investment, and Real Rates," *Carnegie Rochester*

Conference Series in Public Policy, 39: 95–140.

Cukierman, A., S. B. Webb, and B. Neyapti (1992), “Measuring the Independence of Central Banks and its Effects on Policy Outcomes,” *The World Bank Economic Review*, 6: 353–398.

Debelle, G. (1993), “Central Bank Independence: A Free Lunch?,” unpublished manuscript, MIT.

Debelle, G. and S. Fischer (1994), “How Independent Should a Central Bank Be?,” unpublished manuscript, MIT.

De Gregorio, J. (1992), “Economic Growth in Latin America,” *Journal of Development Economics*, 39: 59–84.

De Gregorio, J. (1993), “Inflation, Taxation, and Long-Run Growth,” *Journal of Monetary Economics*, 31: 271–298.

De Gregorio, J. (1995), “Policy Accommodation and Gradual Stabilization,” *Journal of Money, Credit and Banking*, 27: 727–741.

De Gregorio, J. and F. Sturzenegger (1994), “Credit Markets and the Welfare Costs of Inflation,” NBER Working Paper No. 4873.

De Long, B. and L. H. Summers (1992), “Macroeconomic Policy and Long-Run Growth,” *Federal Reserve Bank of Kansas Economic Review*, 77: 5–29.

Dixit, A. and R. Pindyck (1993), *Investment under Uncertainty*, Princeton: Princeton University Press.

Dornbusch, R. and S. Fischer (1993), “Moderate Inflation,” *The World Bank Economic Review* 7: 1–44.

Dornbusch, R. and J. Frenkel (1973), “Inflation and Growth,” *Journal of Money, Credit and Banking*, 5: 141–156.

Driffill, J., G. Mizon and A. Ulph (1990), “Costs of Inflation,” in Friedman B. and F. Hahn (eds.), *Handbook of Monetary Economics*, Amsterdam: North Holland.

Easterly, W. (1994), “Economic Stagnation, Fixed Factors, and Policy Thresholds,” *Journal of Monetary Economics*, 33: 525–557.

Fischer, S. (1983), “Inflation and Growth,” NBER Working Paper No. 1235 (published as “Inflación y Crecimiento,” *Cuadernos de Economía*, 20: 267–278).

Fischer, S. (1991), “Growth, Macroeconomic, and Development,” *NBER Macroeconomics Annual*, 6: 329–364.

Fischer, S. (1993), “The Role of Macroeconomics Factors in Growth,” *Journal of Monetary Economics*, 32: 485–512.

Fischer, S. (1995), “Modern Approaches to Central Banking,” NBER Working Paper No. 5064.

Fischer, S. and F. Modigliani (1978), “Towards and Understanding of the Real Effects and Costs of Inflation,” *Weltwirtschaftliches Archiv*, 810–832.

- Friedman, M. (1969), "The Optimal Quantity of Money," in *The Optimum Quantity of Money and Other Essays*, Chicago: Aldine.
- Garfinkel, M. and S. Oh (1993), "Strategic Discipline in Monetary Policy with private Information," *American Economic Review*, 83: 99–117.
- Gomme, P. (1993), "Money and Growth Revisited: Measuring the Costs of Inflation in an Endogenous Growth Model," *Journal of Monetary Economics*, 32: 51–77.
- Grier, K.B. and G. Tullock (1989), "An Empirical Analysis of Cross-National Economic Growth, 1951–1980," *Journal of Monetary Economics*, 24: 259–276.
- Grilli, V., D. Masciandano and G. Tabellini (1991), "Political and Monetary Institutions and Public Financial Policies in the Industrial Countries," *Economic Policy*, 13: 341–392.
- Grossman, G. and E. Helpman (1991), *Innovation and Growth in the Global Economy*, Cambridge, Mass.: MIT Press.
- Hartman, R. (1972), "The Effects of Price and Cost Uncertainty on Investment," *Journal of Economic Theory*, 5: 285–266.
- Jones, L.E. and R.E. Manuelli (1990), "A Convex Model of Equilibrium Growth: Theory and Policy Implications," *Journal of Political Economy*, 98: 1008–1038.
- Jones, L.E. and R.E. Manuelli (1993), "Growth and the Effects of Inflation," NBER Working Paper No. 4523.
- King, R. and R. Levine (1993), "Finance, Entrepreneurship, and Growth: Theory and Evidence," *Journal of Monetary Economics*, 32: 513–542.
- Kormendi, R.C. and P.G. Meguire (1985), "Macroeconomic Determinants of Growth: Cross-Country Evidence," *Journal of Monetary Economics*, 16: 141–163.
- Kydland, F.E. and E. C. Prescott (1977), "Rules Rather than Discretion: The Inconsistency of Optimal Plans," *Journal of Political Economy*, 85: 473–492.
- Lach, S. and D. Tsiddon (1992), "The Behavior of Prices and Inflation: An Empirical Analysis of Disaggregated Price Data," *Journal of Political Economy*, 100: 349–389.
- Leijonhufvud, A. (1977), "Costs and Consequences of Inflation," in: Harcourt, H. (ed.), *Microeconomic Foundations of Macroeconomics* Boulder, CO: Westview Press.
- Levhari, D. and D. Patinkin (1968), "The Role of Money in a Simple Growth Model," *American Economic Review*, 58: 713–753.
- Levine, R. and D. Renelt (1992), "A Sensitivity Analysis of Cross-Country Growth Regressions," *American Economic Review*, 84: 942–963.
- Levine, R. and S. Zervos (1993), "Looking at the Facts: What We Know about Policy and Growth from Cross-Country Analysis," Working Paper No. WPS 1115, The World Bank.
- Lohmann, S. (1992), "Optimal Commitment in Monetary Policy: Credibility versus

- Flexibility," *American Economic Review*, 82: 273-280.
- Lucas, R.E. (1988), "On the Mechanics of Economic Development," *Journal of Monetary Economics*, 22: 3-42.
- Lucas, R. (1993), "On the Welfare Costs of Inflation," unpublished manuscript, University of Chicago.
- McClandess, G.T. and W.E. Weber (1995), "Some Monetary Facts," *Federal Reserve Bank of Minneapolis Quarterly Review*, 19(3): 2-11.
- McDonald, R. and D. Siegel (1985), "The value of Waiting to Invest," *Quarterly Journal of Economics*, 101: 707-728.
- McKinnon, R. (1973), *Money and Capital in Economic Development*, Washington D.C.: Brookings Institution.
- McKinnon, R. (1991), *The Order of Economic Liberalization: Financial Control in the Transition to Market Economy*, Baltimore and London: Johns Hopkins University Press.
- Mundell, R. (1965), "Growth, Stability and Inflationary Finance," *Journal of Political Economy*, 73: 97-109.
- Murphy, K., A. Shleifer and R. Vishny (1991), "The Allocation of Talents: Implications for Growth," *Quarterly Journal of Economics*, 104: 503-530.
- Orphanides, A. and R.M. Solow (1990), "Money, Inflation and Growth," in: B. Friedman and F. Hahn, eds., *Handbook of Monetary Economics*, Amsterdam: North Holland.
- Persson, T. and G. Tabellini (1993), "Designing Institutions for Monetary Stability," *Carnegie Rochester Conference Series in Public Policy*, 39: 53-84.
- Pindyck, R. and A. Solimano (1993), "Economic Instability and Aggregate Investment," *NBER Macroeconomics Annual*, 8: 259-303.
- Rebelo, S. (1991), "Long-Run Policy Analysis and Long-Run Growth," *Journal of Political Economy*, 99: 500-521.
- Rogoff, K. (1985), "The Optimal Degree of Commitment to an Intermediate Monetary Target," *Quarterly Journal of Economics*, 100: 1161-1190.
- Romer, P.M. (1986), "Increasing Returns and Long-Run Growth," *Journal of Political Economy*, 95: 1002-1037.
- Roubini, N. and X. Sala-i-Martin (1992), "Financial Repression and Economic Growth," *Journal of Development Economics*, 39: 5-30.
- Sarel, M. (1995), "Nonlinear Effects of Inflation on Economic Growth," IMF Working Paper WP/95/56.
- Shaw, E. (1973), *Financial Deepening in Economic Development*, New York: Oxford University Press.
- Sidrauski, M. (1967), "Rational Choice and Patterns of Growth in a Monetary Econ-

- omy," *American Economic Review Papers and Proceedings*, 534–544.
- Stiglitz, J. and A. Weiss (1981), "Credit Rationing in Markets with Imperfect Information," *American Economic Review*, 71: 393–410.
- Stockman, A.C. (1981), "Anticipated Inflation and the Capital Stock in a Cash-In-Advance Economy," *Journal of Monetary Economics*, 8: 387–393.
- Summers, R. and A. Heston (1991), "The Penn World Table (Mark 5): An Expanded Set of International Comparisons," *Quarterly Journal of Economics*, 104: 327–368.
- Tobin, J. (1965), "Money and Economic Growth," *Econometrica*, 33: 671–684.
- Tommasi, M. (1993), "High-Inflation: Resource Misallocations and Growth Effects," unpublished manuscript, UCLA.
- Ungar, M. and B. Zilberfarb (1993), "Inflation and its Unpredictability—Theory and Empirical Evidence," *Journal of Money, Credit and Banking*, 25: 709–720.
- Végh, C. (1992), "Stopping High Inflation: An Analytical Overview," *IMF Staff Papers*, 39: 629–695.
- Walsh, C. E. (1993), "Central Bank Strategies, Credibility, and Independence: A Review Essay," *Journal of Monetary Economics*, 32: 287–302.
- Walsh, C. E. (1994), "Central Bank Independence and the Costs of Disinflation in the EC," unpublished manuscript, University of California, Santa Cruz.
- Walsh, C. E. (1995), "Optimal Contracts for Central Bankers," *American Economic Review*, 85: 150–167.

Table 1: Growth and Inflation: Cross-Section (1960–85)

Indep. Variable Regression No.:	Dependent variable: Growth GDP per capita 1960–85 Coefficient (t- statistics)					
	1.1	1.2	1.3	1.4	1.5	1.6
Sample	All countries	All countries	All countries	All countries	Indust. countries	Develop. countries
Inflation ^a	-0.0057 (-2.86)		-0.0051 (-2.81)		-0.0042 (-2.43)	-0.0071 (-2.75)
High Inflation ^a (≥20%)		-0.0050 (-2.23)		-0.0040 (-1.94)		
Low Inflation ^a (<20%)		0.0038 (0.93)		0.0024 (0.64)		
Investment Rate			0.091 (2.85)	0.093 (2.93)		
SEC60 ^b	0.032 (2.90)	0.032 (2.86)	0.021 (1.93)	0.021 (1.89)	0.016 (2.86)	0.041 (2.08)
PRIM60 ^b	0.040 (5.18)	0.040 (5.28)	0.029 (3.65)	0.029 (3.76)	0.009 (1.07)	0.039 (4.05)
Government Consumption	-0.147 (-4.17)	-0.149 (-4.21)	-0.150 (-4.76)	-0.154 (-4.67)	-0.036 (-1.25)	-0.179 (-4.41)
log(initial GDP)	-0.016 (-4.20)	-0.016 (-4.06)	-0.016 (-4.76)	-0.016 (-4.67)	-0.026 (-6.33)	-0.015 (-3.10)
R ²	0.48	0.48	0.55	0.55	0.72	0.51
No. obs.	84	84	84	84	21	63

Standard errors computed using White's robust procedure.

^a Log of the inflation rates.

^b SEC60 (PRIM60): Secondary (primary) school enrollment ratio in 1960.

Table 2: Growth and Inflation: Subsamples and Outliers

Indep. Variable Regression No.:	Dependent variable: Growth GDP per capita 1960–85 Coefficient (t- statistics)				
	2.1	2.2	2.3	2.4	2.5
Sample	All countries	All countries ^c	Develop. countries ^c	Develop. countries	Develop. countries ^c
Inflation ^a	-0.0036 (-1.68)	-0.0047 (-2.02)	-0.0061 (-2.25)		
High Inflation ^a (≥20%)				-0.0046 (-1.42)	-0.0053 (-1.63)
Low Inflation ^a (<20%)				0.0043 (0.79)	0.0042 (0.77)
SEC60 ^b	0.030 (2.58)	0.029 (2.52)	0.036 (1.63)	0.037 (1.66)	0.035 (1.57)
PRIM60 ^b	0.036 (4.89)	0.036 (4.83)	0.036 (3.85)	0.037 (3.80)	0.037 (3.84)
Government Consumption	-0.155 (-4.85)	-0.165 (-5.12)	-0.206 (-5.21)	-0.190 (-4.79)	-0.208 (-5.18)
log(initial GDP)	-0.017 (-5.28)	-0.018 (-5.50)	-0.018 (-4.41)	-0.017 (-4.08)	-0.018 (-4.32)
Revolutions and Coups	-0.019 (-2.42)	-0.028 (-3.02)	-0.028 (-2.77)	-0.018 (-2.08)	-0.029 (-5.18)
R ²	0.52	0.58	0.57	0.54	0.57
No. obs.	84	81	60	63	60

^a Log of the inflation rates.^b SEC60 (PRIM60): Secondary (primary) school enrollment ratio in 1960.^c Excludes Argentina, Bolivia and Peru

Table 3: Investment and Inflation: Cross-Section (1960–85)

Indep. Variable Regression No.:	Dependent variable: Investment Rate 1960–85 Coefficient (t- statistics)					
	3.1	3.2	3.3	3.4	3.5	3.6
Sample	All countries	All countries	All countries	Indust. countries	Develop. countries	High inf. countries
Inflation ^a	-0.016 (-1.32)	-0.007 (-0.76)		-0.009 (-0.55)	-0.009 (-0.92)	0.012 (0.78)
High Inflation ^a (≥20%)			-0.010 (-0.98)			
Low Inflation ^a (<20%)			0.015 (0.94)			
SEC60 ^b		0.123 (2.13)	0.123 (2.11)	0.064 (0.84)	0.188 (2.35)	0.065 (0.78)
PRIM60 ^b		0.118 (4.53)	0.117 (4.58)	-0.006 (-0.09)	0.103 (3.87)	0.039 (0.17)
Government Consumption			0.050 (0.35)	-0.328 (-1.88)	0.121 (0.75)	
log(initial GDP)		-0.002 (-0.15)	-0.002 (-0.11)	-0.030 (-0.88)	0.004 (0.23)	0.051 (1.46)
R ²	0.02	0.54	0.54	0.13	0.46	0.58
No. obs.	84	84	84	21	63	13

Standard errors computed using White's robust procedure.

^a Log of the inflation rates.

^b SEC60 (PRIM60): Secondary (primary) school enrollment ratio in 1960.

Table 4: CBI, Inflation and Growth in OECD countries

	GMTAS	CWN	Inflation	Growth
Australia	2	0.31	6.8	2.1
Belgium	2	0.19	5.6	3.2
Canada	2.5	0.46	5.8	2.8
Denmark	2.5	0.47	7.9	2.7
France	2	0.28	7.4	3.2
Germany	4	0.66	3.8	2.9
Italy	1.75	0.22	9.9	3.3
Japan	2.5	0.16	6.5	5.8
Netherlands	2.5	0.42	5.5	2.6
Norway	2	0.14	7.0	3.7
New Zealand	1	0.27	8.9	1.4
Spain	1.5	0.21	11.0	3.9
Sweden	2	0.27	7.1	2.6
Switzerland	4	0.68	4.2	1.8
United Kingdom	2	0.31	8.6	2.2
United States	3.5	0.51	5.4	2.1

Sources: Alesina and Summers (1993), Cukierman (1993), IFS and Summers and Heston (1991).

Table 5: **Regressions Results for Inflation**

Sample	Legal Indepen.	Turnover Rate	R^2	n. obs.
Dependent Variable: $\pi/(1 + \pi)$				
All Countries	0.076 (0.66)	0.368 (4.35)	0.29	51
All Countries		0.368 (4.42)	0.28	52
All Countries ^a		0.213 (2.09)	0.08	51
OECD Countries	-0.066 (-2.278)	-0.003 (-0.03)	0.42	15
Developing Countries	0.246 (1.09)	0.394 (3.23)	0.20	32
Developing Countries		0.394 (3.27)	0.26	33
Developing Countries ^b		0.241 (1.34)	0.06	31

t-statistics in parenthesis.

^a Excluding Argentina.

^b Excluding Argentina and Costa Rica.

Figure 1: Inflation and Growth

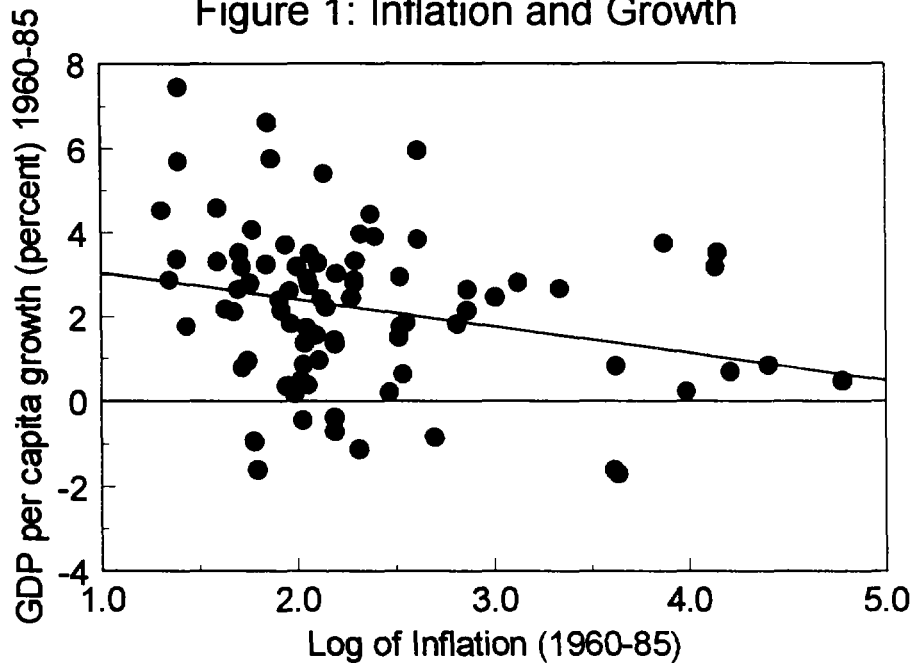


Figure 2: Inflation and Investment

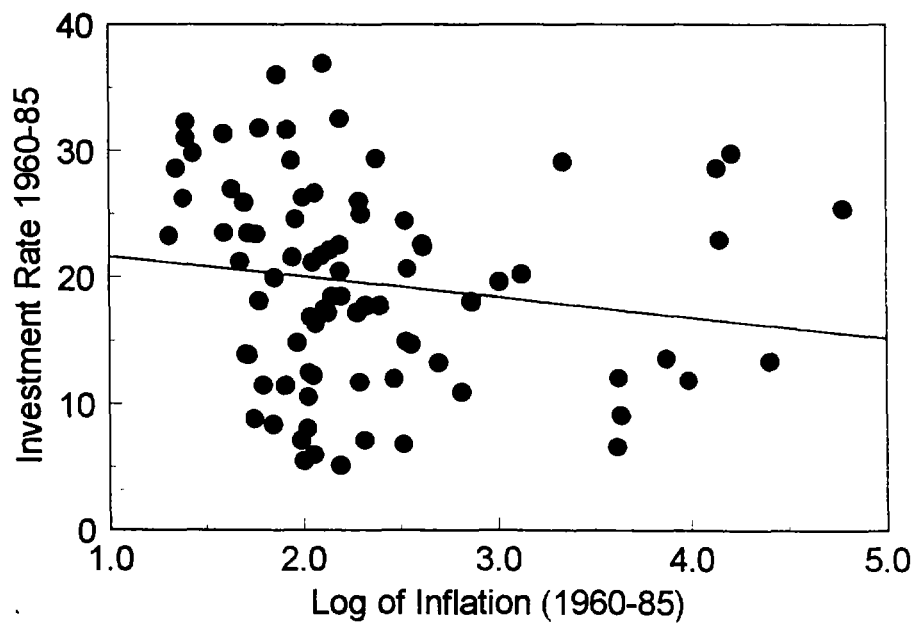


Figure 3: Inflation and Legal independence
(Industrialized countries)

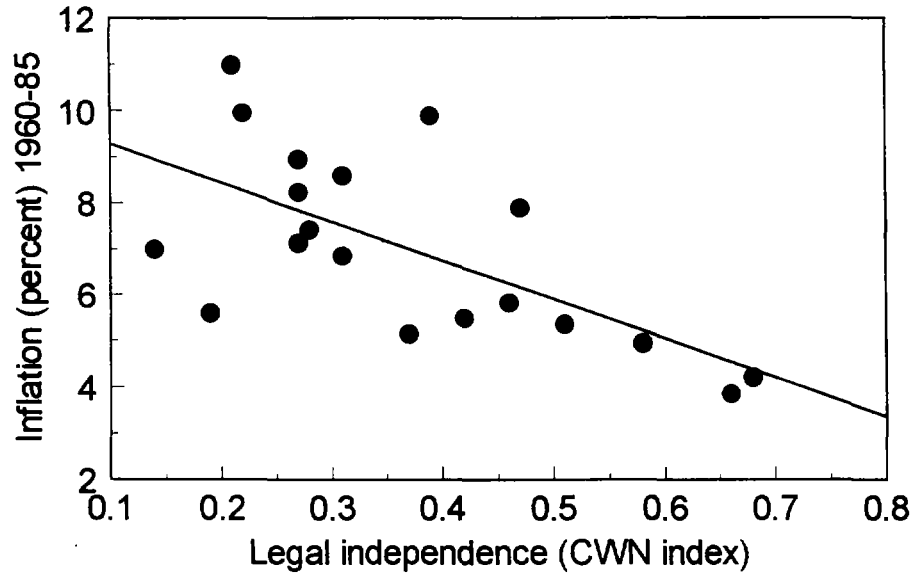


Figure 4: Inflation and Central Bank Independence
(Industrialized countries)

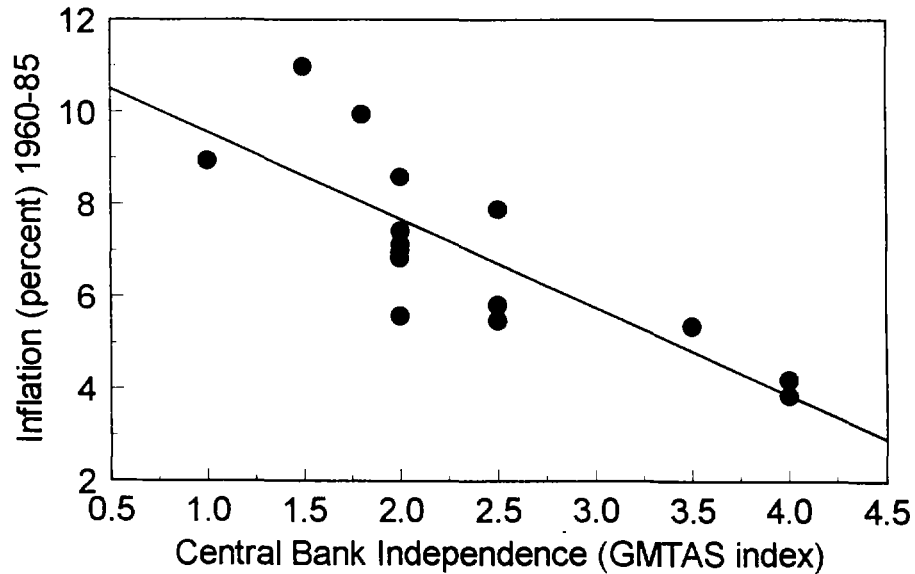


Figure 5: Growth and Central Bank Independence
(Industrialized countries)

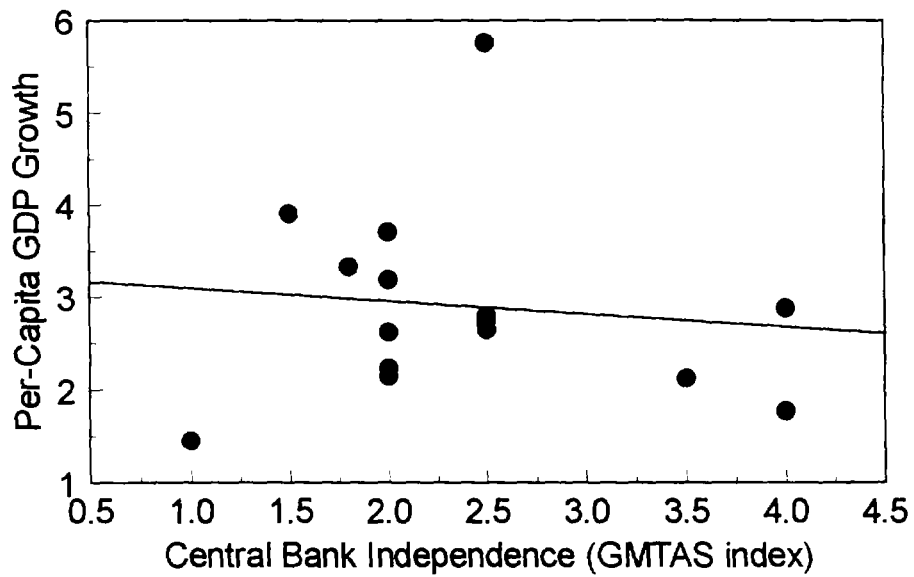


Figure 6: Partial Scatter of Growth and CBI
(Industrialized countries)

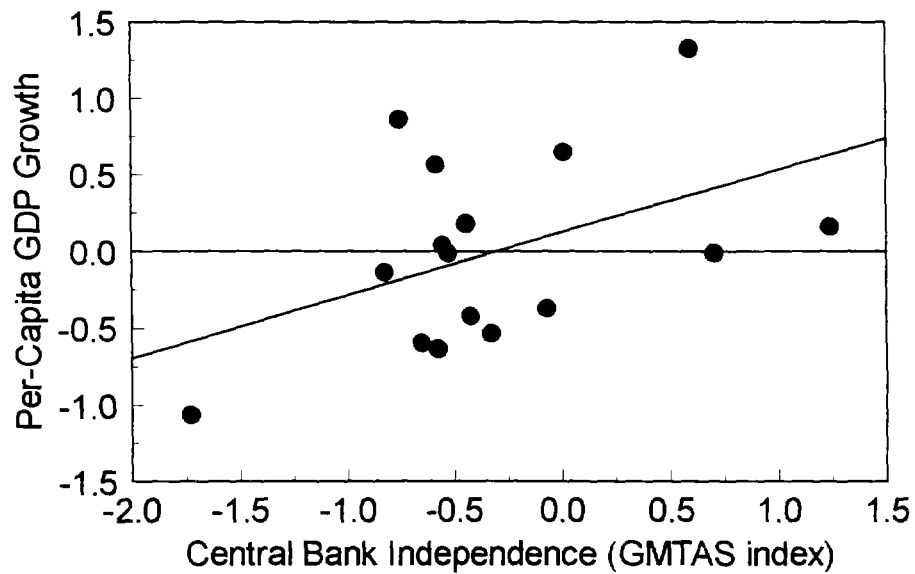


Figure 7: Inflation and Turnover Rates
(Developing Countries)

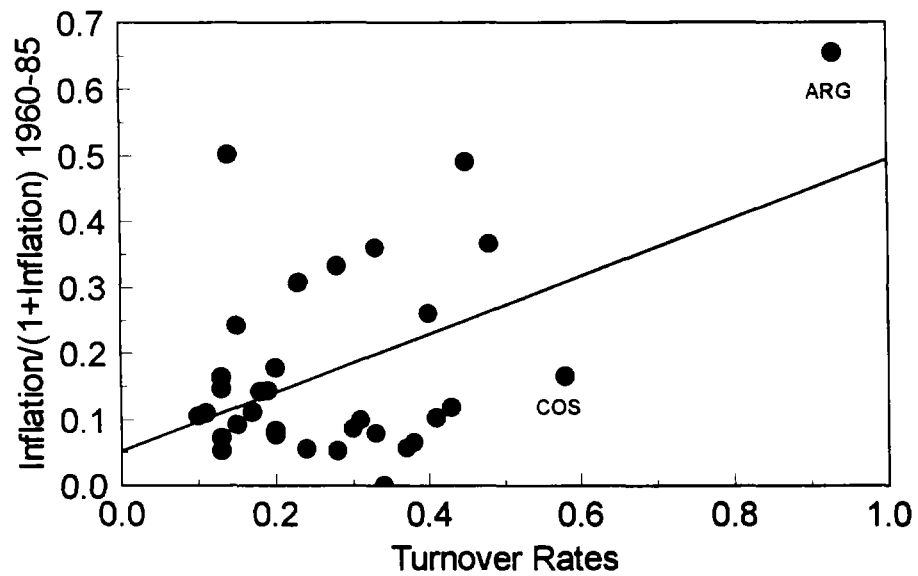
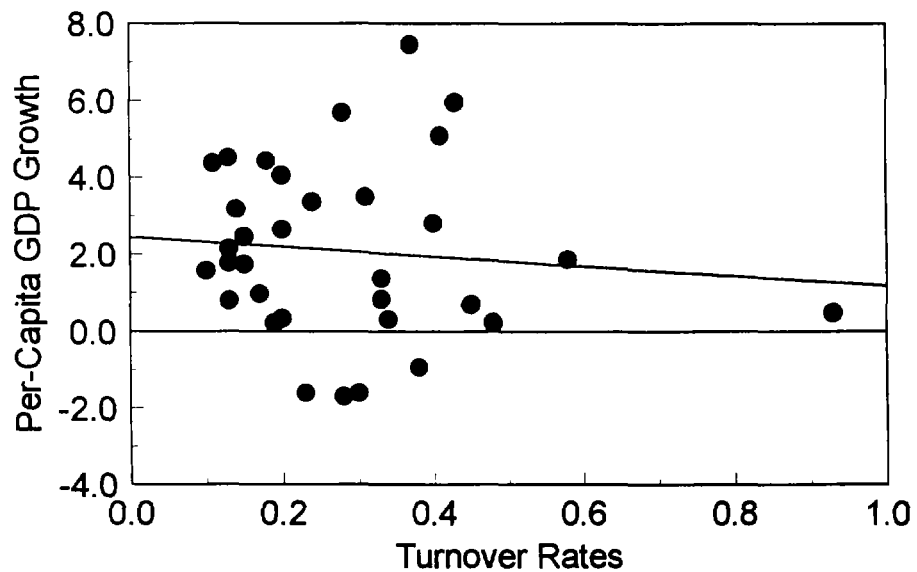


Figure 8: Growth and Turnover Rates
(Developing Countries)



Policy Research Working Paper Series

Title	Author	Date	Contact for paper
WPS1558 In Search of Price Rigidities (Recent Sector Evidence from Argentina)	Jacques Morisset	December 1995	N. Cuellar 37892
WPS1559 Have Transport Costs Contributed to the Relative Decline of Sub- Saharan African Exports? Some Preliminary Empirical Evidence	Azita Amjadi Alexander J. Yeats	December 1995	S. Lipscomb 33718
WPS1560 Trade and Fluctuations	Aart Kraay Jaume Ventura	December 1995	R. Martin 39065
WPS1561 Income Inequality and Aggregate Saving: The Cross-Country Evidence	Klaus Schmidt-Hebbel Luis Servén	January 1996	E. Khine 37471
WPS1562 Catching Up with Eastern Europe? The European Union's Mediterranean Free Trade Initiative	Bernard Hoekman Simeon Djankov	January 1996	F. Hatab 35835
WPS1563 Equity and Growth in Developing Countries: Old and New Perspectives on the Policy Issues	Michael Bruno Martin Ravallion Lyn Squire	January 1996	P. Sader 33902
WPS1564 From Plan to Market: Patterns of Transition	Martha de Melo Cevdet Denizer Alan Gelb	January 1996	C. Rollison 84768
WPS1565 Housing Finance in Transition: Economies: The Early Years in Eastern Europe and the Former Soviet Union	Bertrand M. Renaud	January 1996	R. Garner 37670
WPS1566 Liquidity, Banks, and Markets: Effects of Financial Development on Banks and the Maturity of Financial Claims	Douglas W. Diamond	January 1996	D. Evans 38526
WPS1567 Population Growth, Factor Accumulation, and Productivity	Lant Pritchett	January 1996	S. Fallon 38009
WPS1568 Determinants of Diarrheal Disease in Jakarta	Anna Alberini Gunnar S. Eskeland Alan Krupnick Gordon McGranahan	January 1996	C. Bernardo 37699
WPS1569 Improving Water Resource Management in Bangladesh	Rashid Faruquee Yusuf A. Choudhry	January 1996	C. Anbiah 81275

Policy Research Working Paper Series

	Title	Author	Date	Contact for paper
WPS1570	Protecting the Old and Promoting Growth: A Defense of <i>Averting the Old Age Crisis</i>	Estelle James	January 1996	S. Khan 33651
WPS1571	Export Prospects of Middle Eastern Countries: A Post-Uruguay Round Analysis	Alexander Yeats	February 1996	S. Lipscomb 33718
WPS1572	Averting the Old-Age Crisis: Technical Annex	Robert J. Palacios	February 1996	M. Pallares 30435
WPS1573	North-South Customs Unions and International Capital Mobility	Eduardo Fernandez-Arias Mark M. Spiegel	February 1996	S. King-Watson 31047
WPS1574	Bank Regulation: The Case of the Missing Model	Gerard Caprio, Jr.	February 1996	D. Evans 38526
WPS1575	Inflation, Growth, and Central Banks: Theory and Evidence	José de Gregorio	February 1996	K. Labrie 31001